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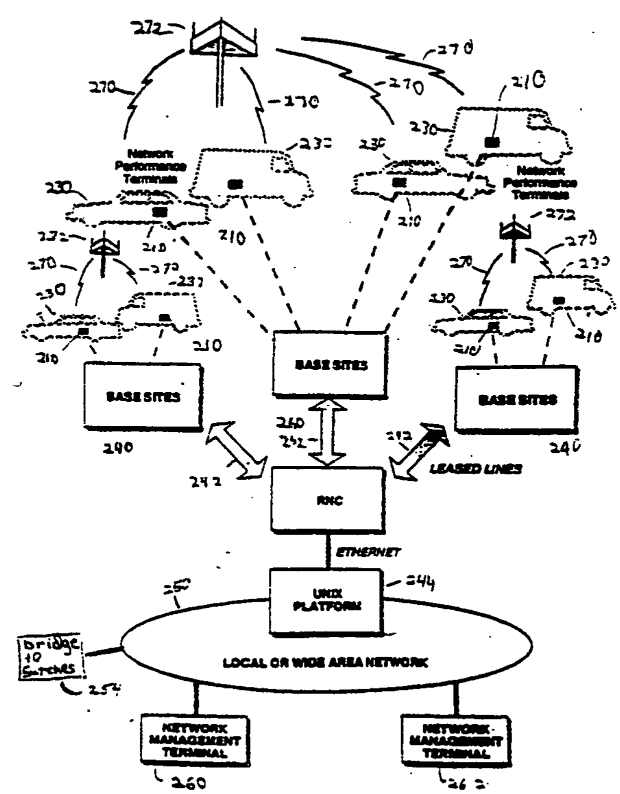
(54) Title: AUTOMATIC CELLULAR TELEPHONE CONTROL SYSTEM

(57) Abstract

Embodiments of an invention for quantitative testing of a radio telephony network are disclosed. An embodiment includes a computer that causes various transceivers to place calls on the network. The computer receives or determines operational parameters of the transceivers or transmission quality associated with those calls and stores the operational parameters for later data processing. Systems for displaying the stored operational parameters on a map are also disclosed.



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AUTOMATIC CELLULAR TELEPHONE CONTROL SYSTEM

Continuation Information

This application is a continuation in part of U.S. Application Serial No. 826,989 filed on January 28, 1992.

Background of the Invention

Field of the Invention

This invention relates to the quantitative evaluation of networks and more particularly to the quantitative evaluation of cellular radio-telephony networks. This invention also relates to automatic testing and control systems and more particularly it relates to the use of real time utilization of test data from the testing of a cellular network to control dynamically that cellular network.

Description of the Prior Art

In a typical cellular radio telephone network, there are a plurality of cells forming a cellular grid across the geographic area to be covered by the network. Each cell comprises at least one fixed base transmitter/receiver station that is coupled to the land line local telephone network via the mobile telephone switching office (MTSO).

Subscribers to the network have mobile telephone transceivers. These transceivers receive incoming calls on a receive channel and make outgoing calls by securing a transmit channel to the transmitter/receiver

station in the cell where the telephone transceiver is currently located. In an ideal cellular telephone network, as the mobile telephone transceiver moves throughout the network and leaves a first cell, the call is "handed off" to the adjacent fixed base station of the next cell or another sector of the same cell site. As part of the hand off procedure, the call from the mobile transceiver is assigned a new channel with the base transmitter in the adjacent cell or sector.

Due to a wide variety of reasons, cellular networks do not always function optimally. For example, when the mobile transceiver attempts to initiate a call to the base transmitter, a channel may not be available if all of the channels are currently being used. Such a situation is called a blocked call. Although a call may not be blocked, the limited number of channels available may extend access time in placing a call.

In addition, when a mobile transceiver moves between cells, a channel may not be available in the new cell. At that point, the call may be interrupted or "disconnected" in classic land-line parlance. Such calls are referred to as dropped calls. A dropped call may also occur without switching cells if there is too much interference or the vehicle may have moved out of range of the cell due to poor network coverage.

Still yet another problem with mobile cellular telephone calls is occasional poor audio quality of the established communication links. Such poor audio quality may result from noise, co-channel and adjacent channel interference, multi-path problems or other common problems associated with radio communications.

Complaints about poor audio quality and dropped or blocked calls have become common to operators of cellular telephone networks. Typically, such networks try to obtain information about the time and the location of the dropped call, blocked call or poor quality of the call. That information may lead to needed modifications of the network such as additional base transmitter/receivers, additional cells or the like.

However, the utility of using customer complaints is limited. Customers typically fail to accurately note the time and location of where a problem occurred. Further, a measurement of poor audio quality during the call is subjective. In addition, since recipients of cellular calls may be less likely to complain to the cellular provider, problems in the transmit channel for the cellular transceiver are less likely to be identified.

Other methods for testing a cellular telephone network include having people traveling throughout the network manually dialling calls. These callers can

record their approximate location, the time of the call, whether they were able to complete the call and the relative quality of the audio. Again, this has been found to be an inadequate method for testing call quality as no quantitative data can be evaluated and accurate positions for where problems may have occurred are difficult to obtain. While the information compiled by technicians is generally more precise, accurate and complete than customer complaints, the information still is not highly accurate, complete and precise as it tends to be of a qualitative nature. Further, it is manpower intensive.

Techniques have been designed for electronically testing and evaluating military communications networks. However, these testing methods have a number of drawbacks. Among the drawbacks of these methods is that the entire cellular network must be committed for the test. However, dedicating the entire network to the test means that subscribers cannot make calls during the test. That has been found to be undesirable.

Additional techniques used for controlling cellular telephone networks is to use propagation models of the system area and to factor weather conditions into the propagation models. In response to different weather conditions, the parameters of the system such as power used, subsites etc. may be

altered. However, propagation models are not capable of determining areas where the network is being overloaded or being subjected to too much electromagnetic interference.

Therefore, it is a first object of this invention to provide a reliable means for testing a cellular network. It is a second object of this invention to provide quantitative measurements of the quality of the available channels. It is still yet another object of this invention to provide an efficient means by minimizing manpower. It is a still further object of this invention to evaluate the network performance without requiring the dedication of the entire network to the test for a given period of time. It is yet another object to test the availability of channels in the network.

It is yet another goal of this invention to provide real time information to the system controllers. It is a further goal of the invention to provide information about the system performance to the system controllers. It is yet another aspect of this invention to provide for automatic control of the cellular network so that the network may be reconfigured in responses to the real time information.

Summary of the Invention

These and other objects are accomplished in the disclosed embodiments of the invention. A disclosed embodiment of the invention includes a mobile platform such as a utility van housing a network stimulator. The stimulator comprises a plurality of the appropriate type of cellular telephone transceivers and a position location device such as a global positioning satellite (GPS) receiver under control of a stimulator computer. Preferably, there is also one or more land-line noise measurement stations at at least one base station coupled to the telephone line.

Under control of the computer over a common bus, the cellular transceivers repeatedly attempt to initiate calls to the base station while the mobile stimulator moves throughout the network. The stimulator computer records the data from the GPS receiver so that the route of the platform may be reconstructed at a later date.

The particular scenario for the operation of the various transceivers is determined by one of a selectable group of scenarios programmed by the user. One transceiver may repeatedly attempt to initiate calls. When a blocked call occurs for that transceiver, the mobile computer records the time and the location of the stimulator in the network.

Another transceiver may makes calls less often but the calls are for a longer duration. The received audio quality of the receive communication channel is quantitatively measured through quiet termination noise analysis, signal to noise ratio, sinad measurement techniques or the like for that receiver. The receive audio quality is recorded by the computer along with the position and the time of each such measurement.

Simultaneously, the land-line noise measurement station monitors the incoming call to measure quantitatively operational parameters associated with the audio channel of the transmit channel through similar techniques. The land-line noise measurement station also records the time of any measured operational parameters.

Additional transceivers on the mobile platform may be controlled to dial on a competitive cellular network to the first network. Thus, quantitative data about the performance of competitive networks may also be obtained. Also, an additional transceiver called a monitor transceiver may monitor adjacent voice and control channels for adjacent channel interference and the like.

The stimulator computer monitors the channels of all calls and sends those channel numbers to a monitor transceiver. The monitor transceiver then scans all used channels plus the adjacent channels along with the

control channels of the networks being analyzed. The monitor transceiver reports this information back to the computer for data storage.

The data accumulated by the computer in the base station and the computer on the mobile platform may be stored and later combined. Using standard database techniques, the data may then be displayed on maps of the network to highlight problems in the network. This data may also be cross-referenced to customer complaints compiled by the customer service department of the network.

In an additional embodiment, one or more mobile units mounted in vehicles are provided with a position location subsystem, at least one cellular transceiver, a controller and a mobile data modem. The controller monitors various parameters associated with calls placed by a subscriber to the network. Parametric data regarding such calls that relate to the performance of the network are transmitted on a real time basis over a high capacity radio data network along with positional information about the location of the call.

As an additional aspect of the invention, the data transmitted over the network may be displayed on monitors for the system controllers. The displays may include monitoring of predetermined conditions such as dropped calls, block calls or predetermined signal to noise levels. As a result, the system operators may

then dynamically reconfigure the network by transmitting over land lines to the cellular switches to alter the power levels, to reassign different or additional frequencies to a cell or to activate subcell transmitters.

As additional alternative embodiments, one or more additional cellular transceivers may be included in each mobile unit for monitoring adjacent channels and co-channel noise. In addition, the mobile unit may be configured to receive scenario commands to cause the mobile unit to initiate certain call scenarios as part of testing the system. These call scenarios may be provided to the mobile unit via the radio data communications network or by field programming of the controllers.

Yet an additional feature of the disclosed embodiments includes having a system controller monitoring the data transmitted from the mobile test units. In response to predetermined conditions in the network, the network may be dynamically reconfigured for automatic, dynamic network system control.

Description of the Figures

FIGURE 1 is a block diagram of a network stimulator according to one embodiment of the invention.

FIGURE 2 is a block diagram of a cellular phone interface/controller shown in Figure 1.

FIGURE 3 is a state diagram for the operation of the interface/controller depicted in Figure 2.

FIGURE 4 is a block diagram of an land-line noise measurement station according to an embodiment of the present invention.

FIGURES 5A, B and C are representative maps produced by using the data gathering techniques described above.

Figure 6 is a subscriber interface test terminal of another embodiment of the disclosed invention.

Figure 7 is a diagram of a cellular phone system and a control computer network for monitoring that system using an embodiment of the disclosed invention.

Figure 8 is a block diagram of a test terminal suitable for use in a delivery van or the like.

Figure 9 is a representative map produced by using the data gathering techniques described above.

Figure 10 is a histogram of the audio signal to show how co-channel interference can be determined.

Figure 11 is a diagram of a further embodiment of the invention for testing paging systems.

Detailed Description of the Invention

Figure 1 shows a block diagram of an embodiment of a mobile network stimulator or network performance terminal 10 that may be used with the present invention. The mobile network stimulator 10 may be mounted on a mobile platform such as a utility van (not shown) or the like. The mobile platform should preferably include a reliable power supply to power the mobile network stimulator 10.

The mobile network stimulator 10 includes a high performance stimulator computer 12 such as a high performance IBM PC compatible computer using a 33 megahertz 80386 microprocessor or more powerful microprocessor acting as a central controller. The stimulator computer 12 should preferably include a keyboard and a monitor, mass storage media 15 such as a one hundred twenty megabyte hard disk drive and a suitable digital signal processor 13 such as a DSP module PCI-20202C-1 along with a compatible analog multiplex module such as a PVI 20002M-1. Both modules for the digital signal processor 13 are available from Intelligent Instrumentation Division of Burr-Brown.

The mobile network stimulator 10 also includes a vehicle location device 14 for ascertaining the vehicle position. The vehicle location device 14 may comprise a Magnavox MX4200 global positioning satellite time/position receiver with dead reckoning capabilities

and should be coupled to a suitable antenna (not shown). Alternatively, a ETAC or a LORAN receiver may also be used. The vehicle location device should also have a connector to the platform speedometer (not shown) to obtain platform speed information for storage on mass storage media 15 in a mobile log file as explained below. The vehicle location device may also include an RS422-RS232 converter so that the vehicle location device 14 may be coupled to a suitable I/O board on the stimulator computer 12.

A stimulator 10 in this embodiment may also include up to eight transceiver assemblies 16 a-h. Each transceiver assembly 16 a-h includes an interface/controller module 18 a-h respectively that allows a cellular transceiver 20 a-h to be controlled by the stimulator computer 12 through a suitable input output board of the stimulator computer 12.

Figure 2 shows a block diagram of the cellular to interface/controller module 18 a-h. Each cellular to interface/controller module 18 a-h includes a microprocessor 180 such as a 68HC11 available from Motorola. The microprocessor 180 is coupled to an RS 232 bus through a port 180a to the host computer 12. In addition, the microprocessor has an address bus output 180b, an internal program EEPROM 180c, a data bus output 180 d, an analog input 180 e along with an internal analog to digital converter 180 d, interrupt

inputs 180 e and an tone output 180 f for providing tones to be transmitted over the radio 20. Each interface/controller module 18 a-h also includes a DTMF transceiver 184, a real time clock chip 186, an external EPROM 188 for storing program data, RAM 190 and an LCD display (not shown) for displaying status information regarding the status of the transceiver assembly 16 a-h. In addition, each interface/ controller 18 a-h has a radio interface 196 that permits the microprocessor 180 to receive various call status information made available by the transceiver 20 a-h. The RSSi signal level is supplied to the analog to digital converter 180 d.

A call progress detector integrated circuit 192 is used along with an energy envelope detector 194 for helping the microprocessor 180 determine if tones generated by the transceiver 20 and/or network are fast busy, reorder, ring signals or the like. An audio interface 198 couples the audio inputs and outputs of the transceiver 20 to the DTMF transceiver 184, the call progress detector 192, to the energy detector 194 and an optional telephone line interface and telephone 199.

Each interface/controller module 18 has four separate operational modes. In the program mode, the microprocessor stores various information necessary for the cellular transceiver 18 to operate with the network

to be tested. In the calibration mode, the interface/controller module 18 is calibrated to the appropriate RSSi levels of the transceiver 20 and interpolation data is stored in the EEPROM 188. In the monitor mode, the transceiver receives channels for monitoring the RSSi and performs the function of a monitor transceiver. In the call mode, the transceiver initiates calls over the cellular network to determine various operational parameters associated with the network. There may yet be a sixth, answer mode where the transceiver receives incoming calls.

Figure 3 shows a partial state diagram for the operation of each interface/controller module 18 a-h in the call mode. In State I 100, the interface/controller is in a wait state. Upon receipt over the RS-232 bus, initialization of the interface/controller module 18 commences in State II 102. During initialization, the interface/controller module 18 a-h receives certain control parameters such as start time over the bus from the computer 12. After initialization, the interface/controller 18 waits for a control channel in State IX 104. If no control channel is available, the interface/controller reports that status in State VI 106 to the computer 12 and returns to State I 100. If the time is adequate, the interface/controller 18 will wait for a system identification in State VIII 108. If State VIII 108

indicates no service, the interface/controller will report that fact over the bus to the computer 12 in State VI 106. Once State VIII 108 has been completed, the interface/controller will send the number over the cellular network to initiate a call in State III 110. The interface/controller module 18 then waits for receipt of a pound (#) signal transmitted by an land-line noise measurement station 30 described below in State IV 112. If no pound symbol is received within a predetermined time period, the absence of the receipt of the pound signal is reported over the RS 232 bus to the computer 12 in State VI 106.

Alternatively, the start of the call may result in a busy condition, a reorder or a dropped call. In State VII 114, the interface controller 18 determines if the maximum number of retries to initiate a call has been exceeded. If the maximum number has not been exceeded, the interface controller module 18 returns to State IX 104. If the maximum number has been exceeded, data regarding the number of attempts is reported by the interface controller at State VI 106 to the computer 12.

If the pound signal is detected, the interface controller module 18 enters State V 116. If the call is dropped, the interface controller goes to State VII 114. Otherwise, the call will eventually exceed the maximum duration and be terminated.

During State V 116, various operational parameters such as signal to noise ratio, and quiet line noise termination may be determined by the digital signal processor 13 for storage on the mass media 15. Other operational parameters associated with the ongoing call may also be provided to the computer 12 for storage. In addition, the date and time of the call may be transmitted over the audio channel by the DTMF transceiver 184. After completion of State V, the completion of the call is reported in State VI 106.

Moreover, a particular one of transceiver assemblies 16 a-h may only be used for determining network access time. In that event, upon detection of the pound (#) symbol in State IV 112, the interface/ controller module 18 a-h will cause to transmit over the voice channel through the network the appropriate call identification. That call identification may be comprised of a number assigned in sequence for a call identification, a transceiver assembly number and the call type for that transceiver. Subsequent to the transmission of the call identification, the interface/controller module 18 a-h enter state V 106. The network access time will be reported to the computer 12 over the bus.

The transceiver 20 a-h should be suitable for with the type of cellular network to be tested and may be a Model M-20 or M-21 available from Oki. Alternatively,

as is appropriate for the network being tested, any computer controllable transceiver such as a GSM, Fleet Call, Analog, TDMA, ETDMA, CDMA, TACS, ETACS, JTACS, NMT and Japanese digital type transceiver may be used. Each transceiver 20 a-h should be coupled through a co-axial cable (not shown) to a suitable cellular antenna (not shown).

Also included in the network stimulator 10 is an audio multiplexer 22 that couples the receive audio channel of each transceiver 20 a-h to the digital signal processor 13. The digital signal processor 13 may sequentially sample the audio for the receive channel of each transceiver 20 a-h to determine the signal to noise ratio, the audio spectra of the receive audio channel and to perform sinad measurement or to perform quiet termination noise analysis for the designated one or more of the transceivers 20 a-h in real time. As explained below, the data produced by the digital signal processor may be stored on the mass storage media 15 of the stimulator computer 12 in an mobile log file.

In a preferred embodiment of the invention, at least one fixed site network land-line noise measurement station 30 as shown in Figure 4 may be used. This land-line noise measurement station 30 includes a digital signal processor 32 identical to the processor 13 in the stimulator 10 and has at least two

suitable jack sockets such as RJ11 sockets 34 for connection to ordinary telephone land lines. Further the network land-line noise measurement station 30 includes a processor 32, a DTMF transceiver 36, mass storage media 38 and tape backup 39 for that mass storage media 38. The digital signal processor 32 sequentially samples the receive audio for each incoming phone call over a multiplexer 35 and determines the signal to noise ratio, analyzes the audio spectra, performs a sinad measurement or quiet termination noise analysis of the transmit audio channels of any incoming calls. The DTMF transceiver 36 answers incoming calls and exchanges pertinent information with the interface/controller 18 a-h via the transceiver 20 a-h, the cellular network and the land lines. The transmitted information may include instructions such as start sinad test signals, the time detected by the global positioning satellite time/position receiver, the date, call conditions and information relating to other operational and control parameters for the appropriate transceiver assembly 16 a-h. Appropriate data is stored in an answer log file on the mass storage of the fixed site network land-line noise measurement station.

The cooperative operation of the mobile network stimulator 10 and the fixed site network land-line noise measurement station 30 will now be described. As

the mobile vehicle (not shown) containing the stimulator 10 starts to drive through a preselected portion of the cellular network, operators turn on the stimulator computer 12, the vehicle location device 14, and each of the transceiver assemblies 16 a-h and the land-line noise measurement station.

The stimulator computer 12 in the mobile van operates through the respective interface/controller module 18 a-h upon each of the transceivers 20 a-h. The operations of the computer 12 are under control of a predetermined program that implements one or more user designated testing scenarios. Control parameters representative of a scenario may be manually entered via a keyboard into the computer by the operator in response to prompts on a command menu displayed on the monitor of the stimulator computer 12. Alternatively, control parameters may be pre-programmed in a file format compatible with the control program for the stimulator computer 12.

In response to the control parameters for the program, the stimulator computer 12 frequently causes at least one of the transceivers 20 a-h to initiate telephone calls over at least one cellular network. The stimulator computer 12 sends the appropriate control parameters for a transceiver through the appropriate interface/controller module 18 a-h of the appropriate transceiver 20 a-h. These control

parameters for a given transceiver may include the number to be dialed, the duration of each call, the frequency for redialing that number, when to end the call, the channel to monitor or to make a call on or the like. Preferably, the number to be called should be the number for a line connected to the land-line noise measurement station.

The stimulator computer 12 monitors the status of each of those transceivers 20 a-h through the appropriate one of the interface/controller modules 18 a-h and through the digital signal processor 13. Operational parameters associated with each of the transceivers 20 a-h that permit the computer 12 to determine network performance are sent through the appropriate interface/controller module 18 a-h to the stimulator computer 12 for recording on the mass storage device. The operational parameters from the transceiver assembly 16 a-h may include the period of time before a call is initiated, the specific channel on which the outgoing call is initiated, the RSSi, whether the call has been blocked, whether the service is unavailable, how often the transceiver is handed off during a call and whether the call has been dropped.

In some instances, the computer 12 may have to process the operational parameters associated with the call to derive the desired operational parameter from other operational parameters. For example, parameters

regarding the status of the call such as the duration may have to be derived from the time when the transceiver 20 started and ended a call. Thus, determination of operational parameters may involve both direct measurement and derivation through various calculations. In addition, the computer 12 may store an operational parameter only when the change in the operational parameter exceeds a predetermined difference.

Through the use of the digital signal processor 13, the computer also monitors the signal to noise ratio in each of the receive channels, performs spectral analyses for each of the channels, measures quiet termination noise or the like.

Any of the desired data may be recorded on the mass storage media 15 of the computer 12 in one or more data files for later analysis along with the time of the measurement of the various operational parameters. The stimulator computer 12 regularly receives data from the vehicle location device 14 and records the position and velocity of the vehicle of the network stimulator 10 along with the time the vehicle was at a given location.

In a like manner, the network land-line noise measurement station 30 regularly samples the noise quality of the incoming calls to determine the quality of the audio on the receive channel of each

transceivers 20 a-h and records the data and the time of the measurement on a suitable recording medium. In a preferred embodiment of the instant invention, the clocks of the two computers should be synchronized by transmitting over the transmit channel the time of the stimulator computer 12, which is locked to the time detected by the global positioning satellite receiver or to the master clock of the mobile telephone switching office (MTSO) equipment. Still further, the land-line noise measurement station 30 may also initiate telephone calls through a modem to the cellular telephones located in the stimulator 10.

In an embodiment of the invention, a typical scenario controlled by the stimulator computer 12 is for two transceiver assemblies 16 a-b to initiate calls over different, competitive cellular networks at a high rate. A purpose of the high rate of calls is to obtain information about network access time, the frequency and the location of blocked calls and of no service situations, multiple co-channel interference and the current system identification to evaluate ROAM areas.

Under this typical scenario, two additional transceivers make a phone call to the land-line noise measurement station 30 over the two networks with each call having a relatively long duration. The stimulator computer 12 through the digital signal processor 13

monitors these transceiver assemblies 16 c-d to determine audio quality for the receive channel of the transceivers 20 c-d. The stimulator computer 12 also monitors the transceivers 20 c-d through the interface/controller modules 18 c-d for dropped calls and handed off calls. In addition, the land-line noise measurement station 30 may monitor the incoming call and use the digital signal processor 32 of the land-line noise measurement station 30 to monitor the audio transmit channel of the transceivers 20 c-d.

Further, a fifth transceiver assembly 16 e receives the channel number for at least some of the other four transceiver assemblies 16 a-d. The fifth transceiver, called a monitor transceiver, may be used for monitoring control channels and adjacent channels and for measuring co-channel interference on the voice channels. Co-channel interference may be measured by continuing to monitor the RSSi for a given channel after the handoff of a call on that channel and after termination of a call on that channel. During a few second interval after the occurrence of either of those events, the cell will not use the channel for a call. Adjacent channel interference may be measured by having the monitor transceiver assembly 16 e monitors operational parameters associated with the voice channels adjacent to the channels being used by transceivers assemblies 16 a through d and all control

channels. In addition, the fifth transceiver assembly 16 e may also occasionally monitors RSSi for all of the 42 transmit and receive control channels available for the two competitive cellular networks. Still yet additional transceivers (not shown) may initiate calls to other cellular transceivers (not shown) for additional network testing.

The frequency with which a transceiver initiates a telephone call over the network depends upon the operational parameters that need to be measured. For example, if the only desired operational parameters to be measured concern blocked calls, dropped calls during call setup, access time and no service or other operational parameters associated with call initiation, the duration of a call will be very short. For measuring call operational parameters of noise, hand offs of calls, dropped calls or other parameters associated with an ongoing call, the duration of the call should be made appropriately longer, at least thirty to six hundred seconds long.

After the mobile stimulator 10 has finished with making the necessary calls under the user designated scenario, the mobile log file data stored on the mass storage 15 of the network stimulator 10 and the answer log file stored on the land-line noise measurement station are typically combined into one common data file. The combined data file may be in a dBase

compatible file format suitable for use with the dBase computer program of Ashton-Tate or other commonly available database management software. Since the data for both the stimulator log file and the answer log file are stored according to synchronized clocks of both computers, the data base program is able to correlate the position of the network stimulator 10 for any of the parametric data stored by the land-line noise measurement station.

Mapping software such as Map Info (in the suitable operating system version) available from Map Info may then be used with the stored database information in the merged file. The mapping software can use the stored positional data to correlate the position of various identified operational parameters with the positions on a map representing where the operational parameter was measured. Referring to Figure 5A and 5B, symbols 52 show where blocked calls, dropped calls, poor signal quality or other operational parameters associated with a call are shown on a map defined on a medium such as paper or a video display. Maps allow cellular system engineers or managers to readily identify areas where modifications should be made to the network. In Figure 5C, through the use of operating systems such as Microsoft Windows, it is possible to display the particular quantitative data in separate windows 54 that is represented by each

particular symbol 52. This permits users of the invention to better associate the actual statistical measurements with the location where problems may occur. In addition, as shown in Figure 9, a window may be generated to show parametric data leading up to an event such as a dropped call, so the system engineers may study the various measured parameters to determine the cause of a given effect such as dropped call.

In addition to being used in the disclosed embodiment, the disclosed invention may be included in a cellular phone for a vehicle or the disclosed invention may be used with other types of radio communication networks. An ordinary cellular phone may be modified to include data recording equipment for monitoring the parameters associated with the servicing of the calls placed from that phone. In addition, a position location device such as a global positioning satellite system described above should be coupled to the data recording device. At various times, the data for these parameters may be downloaded from the data recording device in the vehicle.

An example of a use of the invention with other types of networks is the use of the invention for ascertaining system performance of a personal communication system radio network inside a building such as those available from Motorola and Ericcson. Preferably, in such embodiments, the stimulator

comprises a plurality of personal communication system transceivers mounted on a small cart. As the cart moves through the service area of the network within a building, appropriate parametric data may be recorded by a computer mounted on the cart and by a base computer. In addition, the location of the cart may either be provided by a location device such as the use of computerized range finders using triangulation or may be manually entered by the operator.

A still further use of an embodiment of the instant invention is to have stimulators 10 located at fixed sites for dynamic network reconfiguration. By using such transceiver assemblies 18 in a monitor mode, for example, data about the performance of a network cell can be compiled. The data may include RSSi data for all voice and control channels, channel usage information or the like. In addition, one or more transceiver assemblies 16 may initiate calls over the network to determine various operational parameters of interest.

The data from each stimulator 10 regarding operational parameters may be transmitted over a land line or a cellular network from a plurality of such stimulators 10 to a host computer (not shown). That host computer may then dynamically reallocate channels to different cell sites or alter the power output of a

cell transmitter in response to computerized analysis of the data.

Figure 6 is a block diagram of yet another embodiment of the invention with a subscriber interface network performance terminal 210. The network performance terminal 210 is mounted inside the vehicle (not shown) of a subscriber to a cellular network. Also mounted inside the subscriber vehicle is a cellular transceiver 220 such as an Oki Model TRU-001 coupled to a cellular antenna 222. Alternatively, as is appropriate for the network being tested, any computer controllable transceiver such as a GSM, Fleet Call, Analog, TDMA, ETDMA, CDMA TACS, ETACS, JTACS, NMT and Japanese digital type transceiver may be used.

The cellular transceiver 220 is coupled to the internal bidirectional bus 212 of the terminal 210. The terminal 210 includes a terminal controller 214 and a mobile data modem 216 that are both coupled to the internal bus 212. Coupled to the modem 216 is a modem antenna 215. Optionally, the performance terminal 210 may further include a positioning system 218 such as a global positioning satellite (GPS) receiver or antitheft vehicle location system transceivers such as Teletrac available from Pacific Telesis. In addition, the controller 214 may include a digital signal processor to perform operations described above.

In those embodiments that lack a positioning system 218, positioning information may be provided by obtaining from the cellular transceiver 220 the particular cell with which the transceiver 220 is communicating. For more precise positioning, the processor can triangulate position by monitoring the RSSi from different cell sites according to algorithms already used for obtaining the position of the vehicle of a given transceiver 220.

The controller 214 receives certain parametric information from the transceiver 220 for each call placed using the transceiver. The parametric information may include information such as call status, cell site, RSSi strength, and SAT information in the manner described for the embodiment of Figure 1. The controller may also receive the audio signal and use a digital signal processor to perform signal to noise ratio analysis, measure quiet termination noise or the like.

In addition, the terminal 210 may also include a secondary cellular telephone transceiver 217 having an antenna 219 for monitoring adjacent channel interference. In yet another embodiment of the invention, the terminal 210 is contained within the housing of the cellular phone. In such embodiments, rather than using separate processors, digital signal processors and programs, the entire control program,

call scenarios, and digital signal processing functions may be integrated to use the processors, digital signal processors and program memories used for operation of the cellular telephone. Such a phone may be built by adapting the terminal 210 to resemble the shape of an ordinary cellular phone including a microphone and speaker and to include the transceiver 220 within the terminal 210. In that event, the controller 214 may also be the controller for the transceiver 210 and include digital signal processing capabilities.

The controller 214 preferably comprised of a microprocessor and a reprogrammable memory monitors the status of the cellular telephone over the bus 212. The controller 214 detects one or more parameters relating to system performance with respect to the phone 220 such as blocked calls, dropped calls, RSSi, hand offs, co-channel RF noise, co-channel audio spectrum analysis, no service, signal to noise ratios, fast busys and reorders. The controller 214 may also monitor the status of one or more of these parameters periodically or upon a certain predetermined thresholds having been reached.

The controller then causes data representative of the detected parameters to be furnished to the mobile data modem 216 for transmission over a suitable digital radio data network such as the Ardis Network available through Motorola of Schaumburg, Illinois as shown in

Figure 7. Other suitable digital radio data networks may include Celluplan, Mobitex, Ramdata and Cellular Data. Depending upon the maximum data rate for the digital radio data network and other traffic such as from additional terminals 210, the digital radio data network will be unable to carry all data recorded. To reduce the amount of data transmitted over the digital radio data network, different data transmission schema may be utilized for transmitting data. The transmission of the data may only occur upon certain predetermined events, such as the detection of a dropped call, interference above a predetermined limit, blocked call, reorders, RSSi below a predetermined threshold or a no service condition. Such transmission schema may also include transmitting recorded data relating to the performance of the cellular network for only a predetermined time interval before the specific predetermined events have occurred. Alternatively, the data may be transmitted across the digital radio data network at preselected time intervals or at random time intervals based on the digital radio data network's traffic density as directed by a command from a network manager. Still further, the data may be transmitted over the cellular telephone radio network through radio modems on either voice channels or over control channels using packet protocols.

The network performance terminals 210 in the vehicles 230 monitor the cellular transmissions 270 between the cellular base sites 272 and the cellular phones in the vehicles 230. The network performance terminals transmit the data relating to the cellular network parameters to the base sites 240 comprised of multiple modems that are part of the digital radio data network. These base sites are coupled to a the central computer 244 of the digital radio data network over for example leased land lines 242. The network computer is then linked by for example an Ethernet network 250 to one or more network management terminals 260, 262 comprising part of the network 262 used by the system controllers.

Reprogramming of the memory in the controller 214 may be through a number of different means. One means is to reprogram over the digital radio data network by transmitting a new call scenario and causing that scenario to be stored in the reprogrammable memory. Other alternatives for generating a new call scenario are to mount the memory chip or chips containing the scenario in a zero force insertion socket so that the program memory may be readily replaced. Alternatively, a new program providing for additional or changed features and new scenarios may be programmed through a port, via the digital radio data network or by replacement of the memory.

In still yet another embodiment, individual or multiple network performance terminals in specific locales may be reprogrammed through the digital radio data network in specific geographic areas so that a particular testing scenario may be undertaken for a geographically restricted portion of the cellular network. For example, it may be desirable to have one terminal make a call to another terminal in the same area. Such reprogramming may be accomplished by transmitting commands over the digital radio data network causing the controllers to poll the positioning system 218 for the location of the vehicle. Subsequently, those terminals will transmit over the data network their telephone number over the digital network to a controller. That controller may then transmit a new scenario including the phone number of a stimulator in that locale. The controller of the appropriate stimulator will cause that transmitted scenario to be stored in the alterable memory. Alternatively, all vehicles in a given locale may store the new scenario depending upon the commands transmitted over the digital radio data network from a controller as described below.

In an additional embodiment 300 of Figure 8 for installation in a delivery van or the like, two or more cellular transceivers 310 and 312 are mounted within a housing 314 and are coupled to cellular telephone

antennas 316 and 318 mounted on the exterior of the delivery van. The cellular transceivers 310 and 312 are coupled to a controller 320 including a microprocessor and a non-volatile rewritable memory 320a such as a flash memory or an EEPROM. Also coupled to the controller 320 are a program port 322, a positioning system 324, and a mobile data modem 326. The mobile data modem 326 is also coupled to an external antenna 328 mounted on the delivery vehicle.

The delivery van embodiment 300 works in a manner as described above for the embodiment of Figure 1 except that there is no operator. Rather, the scenario data may be stored in a non-volatile rewritable memory 320a by entering new scenario data through the program port 322. Alternatively, the non-volatile memory 320 and the program port 322 may be replaced with a removable scenario data memory module. Still further, the scenario data may be re-written by transmitting data for new scenarios over a digital radio data network such as Ardis. In such instances, before the vehicle departs with the stimulator, the program module may be removed to change the scenario that will be initiated by the embodiment 300. Still further the memory 320a may also contain the program for the controller and that program can be changed or modified through any of the methods described above such as by

reprogramming through the transmission of data over the data network.

Still further embodiments include placing fixed network performance terminals 210 or 300 at the cell sites for testing system performance at the cell sites. These network performance terminals do not initiate calls but rather monitor the same system parameters and provide the measured parameters via land line, a digital radio data network or through unused control channels back to the processor for incoming calls to a cell site for subsequent correlation with the parameters measured by the mobile performance terminals.

In the preferred embodiments, when data relating to system parameters is transmitted from a network performance terminal 10, 210 or 300 to the network management terminals, the data may be compiled into a log file for subsequent data manipulation and correlation. The system managers may then select the information that they desire to see displayed in a number of different formats for use by the network managers. In a preferred embodiment, a map 401 of the entire area covered by the cellular system or portions 400 of that system are displayed on the display or in a window of the display as shown in Figure 9. The map 401 displayed may be Map Info for the appropriate operating system available from Map Info or Atlas

Systems available from Strategic Information. Alternatively, the map 401 or overlay may be for a proprietary system such as those common in propagation models for comparing models with measured conditions. Icons representing various system parameters such as dropped calls, blocked calls, no service 402a-e or the like may be displayed at the location where various of these parameters have occurred. In an additional window 408, the key for these various icons may be displayed.

Further, by moving a mouse icon (not shown) to a location 402g in the map 401 and depressing a predesignated button (not shown) on the mouse (not shown) a third data window 406 may be created on the display providing the detailed parameters regarding a particular call occurring before the predesignated event such as a dropped call. A fourth window 404 showing the key for the information in the data window may also be displayed.

The data window 406 is typical of the information that may be displayed for a dropped call. The columns include: (1) the time that the information was recorded, (2) the channel number of the call, the base to mobile noise measured in dBm by a stimulator 10 or 210, (3) the mobile to base station noise measured in dBm by a stimulator located at the cell site, (4) the RSSi in dBm measured by the mobile unit and the cell

site, (5) adjacent channel carrier to interference ratios (C/A) calculated for the cell sites and the stimulator for the higher adjacent (+1) and the lower adjacent (-1) channels, (6) the mobile transceivers receive and transmit status, (7) the status of the mobile transceiver, (8) the mobile and base supervisory audio tones, (9) the attenuation level of the mobile phone transceiver, and (10) a brief description of the data being displayed. In addition, when a call is dropped as in this example, the co-channel RF signal strength has been measured, showing a carrier to interference ratio of 19 dB for the co-channel, which is at the frequency channel 415 in this example.

Still further, the measured data may be used to improve propagation models used for modeling performance of the network. In particular, based upon comparisons between projected network performance and actual measurements, particularly of the C/I ratio, the accuracy of the propagation model may be improved. Further, by using the actual measurements made with the GPS or other location determining schemes, the resolution of the model may be improved so that separate the model can provide projections for performance in smaller geographic areas.

In addition, the information regarding parameters may be compiled in a database by providing the data transmitted over the network in a comma delimited ASCII

format for compilation using standard database programs such as dBase from Ashton-Tate and RBase from Microrim. That data may then be manipulated to arrive at statistics for a historical basis about parameters related to system performance for different geographic regions within the system. Those parameters may be displayed on a visual display such as in a window containing a display of part of the system area and with icons representing areas with for example high noise levels. The user may then use a mouse to obtain more detailed statistical information by clicking on the designated icon.

Yet a still further application for the disclosed embodiments is to have a high speed work station such as a RISC (reduced instruction set computer) parallel processor monitoring the received data at the network 260 (Figure 7). The RISC processor monitors the incoming data for areas in the cellular network where problems such as dropped or blocked calls are occurring at a rate above a predetermined limit. The RISC processor may also receive information from the cellular switches about traffic loads. Preferably high end processors such as the Motorola MC68000 and 88000 family processors or minicomputers such as Micro-Vax's suitable for use with a UNIX operating system are preferred.

The RISC processor may be operated in response to an expert program and artificial intelligence to determine how well the cellular system is operating throughout the coverage area of the system. The artificial intelligence program using an expert system may readily distinguish between different types of noise that are detected such as adjacent channel interference, co-channel interference, inter-modulation, fading and multipath problems.

For example, adjacent channel interference may be identified by comparing carrier to interference ratios of adjacent channels. Interference ratios above a predetermined level such as -5dB would, absent other overriding factors like an electrical storm for example, be determined to be the cause of an effect such as a dropped call by the processor. In addition, by monitoring for conditions such as cochannel ratios of less than 18 dB, locales having substantial interference may be pinpointed unless other contributors to interference are noted.

Co-channel interference may also be determined through using the digital signal processor in the transceiver for co-channel interference. If while monitoring the channel before call completion, substantially more noise is detected in the frequency band of the audio signal of approximately 400 to 1100 hertz with spectral components 10dB higher than in the

rest spectrum, the cause is likely to be co-channel interference. Figure 10 shows an exemplary histogram of the audio spectra of a channel where the noise between the 400 hertz f7 and 1100 hertz f17 is about 10 dB greater than the ambient noise in the audio spectra.

In addition, the program for the RISC processor may further use measured historical data stored in a relational database for diagnosing trends for the particular system to predict where problems in the cellular system such as dropped and blocked calls are likely to occur. The expert program may also integrate propagation models such as network management system performance models.

In response to the received information and the predictions of problems, the RISC processor may send commands via a bridge 254 to one or more cellular switches or cell sites to increase the transmission power of cells or subcells, allocate more channels to a cell or to activate a sub-site within a cell for example. Still further, the tilt of a network antenna mounted on a rotatable platform at a cell site may be altered in response to a control signal from the host computer transmitted to a cell site antenna to reduce interference. Thus, the cellular system may be dynamically reconfigured in response to the actual conditions present throughout the system for maximum utilization of the spectrum and for minimizing problems

experienced by customers. Alternatively after analyzing the data, the system operator may analyze the data and manually transmit control signals to the cellular switches or cell sites commands for dynamically reconfiguring the network.

In addition to using a separate dedicated processor, the cellular switches may be used for some or all of the computational work discussed above for the processor. In particular, where automatic dynamic reconfiguration of the network is desired, use of the cellular switches for performing the analysis and controlling reconfiguration simplifies the design of the system. Still further, the functions of the land-line noise measurement station 30 may be built into the MTSO switch.

In addition, for cellular systems that desire the dynamic control of the system without the capital cost of the RISC processor system or use of the cellular switches, the measured data may be transmitted over a trunk land line to a central computer or a super computer. That central computer may provide the dynamic network management capability to a variety of such different networks systems as a service bureau. In addition to using a RISC based processor, any CISC processor providing sufficient computing power may be used.

Additional uses of alternative embodiments for the disclosed invention is to provide parametric measurements and/or dynamic control for paging networks, mobile data networks and satellite based mobile telecommunication networks such as Motorola's proposed Iridium system. For testing a paging system by way of example, a mobile van (not shown) similar in construction to the stimulator 10 is used. However, the system 500 in Figure 11 in a mobile van contains one or more pager receivers 502a-b with interfaces 503a-b and a global positioning system (not shown) coupled to a computer 504. The interfaces 503a-b are of similar construction as the interfaces of Figure 2. In response to paging calls placed by a dialer such as a modem 508, preferably coupled to the computer 504 mounted in the van, repetitive paging calls are placed to the paging network for initiating pages. The pagers 502a-b receive the incoming pages. Through the respective interface 503a-b coupled to each pager, the reception of the page is logged by the computer along with the position of the van for correlation with the outgoing call. If no page is logged within a certain time limit of when a call has been placed, a potential gap in the coverage of the paging network may be have been detected. Still further, by mounting circuitry 506 for detecting the paging channel signal strength for both when the paging network is free and when

paging calls are being transmitted, signal strength and signal to noise ratios can be measured calculated and stored. Subsequently, using icons for representing locations where various conditions occurred such as no reception of a page and high signal to noise ratios can be displayed on a map using software such as Map Info as described above with respect to Figure 11.

Still further, for digital radio data networks, such as Ardis, Celluplan and Cellular Data, embodiments of the disclosed invention such as the stimulator 210 may also be used for testing various parameters of the network. Such embodiments typically comprise a mobile van containing a computer implementing one or more testing scenarios. The computer is coupled to one or more digital data modems coupled to an antenna for transmission over the network. One or more computers located at a fixed site are also equipped with at least one modem and are coupled to the digital radio data network through a land line or preferably by being located directly at a receiving station for the network.

Bit error rates can be determined by transmitting messages over the network between the computer in the mobile van and a computer located elsewhere. Each message preferably includes error encoding such as block coding such as BCH or Reed Solomon codes or convolution coding separate from the coding scheme of

the network. When the computer receiving the transmitted message decodes the transmitted message, the computer records for each such message, the number of bit errors, the time of receipt of the message and for the computer located in the van, the position of the receiver.

Packet or frame errors may also be determined from the transmitted messages. Depending upon the protocol used by the network, the computer receiving the transmitted message may record errors such as the absence of a header or a trailer for the frame or the packet, frame or packet lengths exceeding the length indicated in the header, or the like. In addition, channel blockage and dropped links in the network along with positional information may be recorded. Statistics based upon the frequency of such errors may be calculated and correlated with the position of the vehicle.

Still further, such a testing unit may also measure parameters associated with the radio channels such as co-channel and adjacent channel interference, signal strength and signal to noise ratios, in the manner described above for the cellular telephone network embodiments. Both the base site computers and the mobile vans may be programmed to implement a variety of testing scenarios for testing the performance of the network.

The measured parameters such as signal strength or bit errors may be stored along with positional information and time on a storage media of the computer for later compilation. The same type of icons described above may also be used for displaying events along with providing windows for displaying measured parameters occurring before each event.

Also, in both the paging system of Figure 11 and the digital radio data network testing system, different scenarios for testing may be implemented by loading new scenario files into the computer or by selecting among prestored scenario files for use by the program in the computer. These scenarios may also include only recording certain of the measurable parameters and only maintaining storage of parameters that occur before preselected events. Still further for dynamic network management or for real time system monitoring, the data from the various measurements may be relayed for use at a central computer over a digital radio data network.

Further, it should be understood that the foregoing embodiments are illustrative only. For example, the stimulator computer may be any type of processor including a dedicated micro-controller or a hard wired circuit. For an understanding of the true scope of the invention, the claims should be studied.

I claim:

1. A method for determining the quality of a cellular telephone network for a geographical area, the network comprising a plurality of cells having at least one base transmitter in each cell, the base transmitter being coupled to land lines via a mobile telephone switching office, the method comprising:

providing at least one mobile cellular phone moving throughout the area;

repeatedly initiating a call to at least one number over the cellular network;

repeatedly determining at least one operational parameter associated with the call;

determining the position of the apparatus at approximately the time when the parameter of the call is determined; and

recording the operation parameter and the position.

2. The method of claim 1, wherein the parameter comprises one of a group of signal to noise ratio, quiet termination noise analysis, RSSi, adjacent channel interference, co-channel radio frequency interference, co-channel audio spectrum analysis, and the status of the call.

3. The method of claim 1 wherein the method further includes recording the time when the parameter and position are determined.

4. The method of claim 1, wherein at least one parameter is recorded only when the parameter changes by greater than a predetermined amount.

5. An apparatus for quantitatively measuring the quality of a cellular radio-telephone network comprised of a plurality of cells, each cell having a base transmitter, the apparatus comprising:

at least one cellular telephone transceiver;

a positioning determining unit physically associated with said transceiver; and

a processor coupled to the transceiver and the position determining unit, the controller repeatedly

(a) causing the cellular telephone transceiver to initiate calls over the cellular network and recording at least a parameter associated at least with some of the calls; and

(b) determining the position of the transceiver at least on some of the occasions when the parameter is determined and

(c) recording the position and the parameter.

6. A method for displaying on a map for a geographic area to be defined on a medium based upon stored map data, data associated with operational parameters related to calls made on a cellular network, the method comprising:

repeatedly causing the initiation of a call over the network while at different positions and times within the network;

determining and recording operational parametric data and position data associated with at least some of the calls;

selecting certain of the parametric data;

correlating the position data and parameter data with the stored map data; and

displaying with a predetermined symbol on the medium a map indicating for where the selected parametric data was determined.

7. The method of claim 6, the method further being interactive with a user and including:

in response to a user command, selecting one or more of the parametric data determined for the location where a symbol is displayed; and

displaying on the medium the selected parametric data in addition to the symbol.

8. An apparatus for testing the quality of a radio telephony network having a plurality of transmit and receive channels, the testing being done according to at least one testing scenario comprising:

means for providing control data representative of the testing scenario;

at least a first cellular transceiver assembly having a transceiver and an interface controller and adopted to initiate calls over the network, the interface controller responsive to control parameters provided and providing operation parameters associated with the call; and

a central controller including a storage medium, the controller being responsive to at least some of the control data to provide to the control parameters and that stores at least some of the operation parameters on the storage medium.

9. The apparatus of claim 8, further including:

a second transceiver having an interface for receipt of control parameters and providing operational parameters, the transceiver being responsive to the controller and monitors at least one second channel other than the channels on which the first phone has initiated the call and provides operation parameters at the interface related to that second channel and wherein the central controller at least occasionally stores the operation parameters.

10. The apparatus of claim 9, wherein the channels monitored by the second transceiver is at least one channel adjacent to the channel for the call of the first transceiver.

11. The apparatus of claim 8, wherein the control parameters comprise at least one of the group of phone number, call duration, number of retries, and redialing frequency for the call.

12. The apparatus of claim 8, wherein the operational parameters comprise at least one of the group of call status, RSSi, time out retries, connect time, the transmit channel for the call to be made on, power level for the transceiver, call hand offs, signal to noise ratio, adjacent channel interference, co-channel radio frequency interference, co-channel audio spectrum analysis and quiet termination noise analysis.

13. The apparatus of claim 9, further including a digital signal processor means coupled to receive the audio signal from at least one transceiver, wherein the signal processor means calculates spectra of the audio signal to determine the type of interference that the transceiver is experiencing.

14. The apparatus of claim 13, further including means for examining the spectra for frequencies between about 400 and 1100 hertz having a level of at least about 10 dB greater than the spectra of the level of other frequencies.

15. The apparatus of claim 8, further including a position location device for determining the geographic location of the apparatus and wherein the controller receives the geographic position of the apparatus for storage on the media.

16. A method for testing a radio telephony network comprised of a plurality of transmit and receive channels according to a testing scenario pursuant to definable control parameters, the method comprising:

providing at least a first cellular transceiver having an interface, the cellular transceiver receiving control parameters at the interface for controlling the operation of the transceiver and presenting operation parameters associated with the call at the interface;

providing over a period of time different control parameters to the interface; and

recording over a period of time the operation parameters on a suitable media.

17. The method of claim 16, wherein the transceiver may be at a plurality of different positions within the network and wherein the method further comprises determining the position of the transceiver in the network when the control parameters are recorded and recording said position.

18. A method for determining adjacent channel interference on a cellular radio telephony network, the method comprising:

making a call on the network with a first transceiver at at least one position;

determining the channel for the call of the first transceiver;

measuring the RF noise on said channel and on at least one adjacent channel with a second transceiver at the same position;

monitoring the carrier to interference ratio on the adjacent channel; and

recording the measured ratio.

19. The method of claim 18, wherein the method further comprises:

determining the position of the transceivers and recording the position of the transceivers at approximately the time the measurement is made.

20. A method for determining co-channel interference on a cellular radio telephony network including a plurality of base stations, the network having a plurality of channels and including means for handing off a call made over the network to another channel, the network using at least some of the same channels in at least two cells, thereby establishing co-channels, the method comprising:

making a call on the network with a first transceiver at at least one position on a first channel;

determining the channel for the call of the first transceiver;

monitoring the first channel for a brief time period after at least one of a hand off or a termination of the call to determine an operational parameter on the associated co-channel of the first channel; and

recording the determined co-channel parameter.

21. The method of claim 20, the method further comprising:

determining at least one of the time that the operational parameter for the co-channel was determined and the position of the transceiver when the operational parameter for the co-channel was determined; and

recording the determined time or position.

22. A method for testing a cellular radio telephony network comprising:

providing a first telephone transceiver

initiating a call on that transceiver to at least one telephone number;

coupling a computer to be responsive to an incoming call at that number to establish a connection between the transceiver and the computer; and

measuring quality of the audio channel of the incoming call and storing data representative of that call.

23. A method for dynamically reconfiguring a cellular network, the network comprised of a plurality of cells, each cell having a plurality of channels for communication and each cell having at least one transmitter having a controllable power level, wherein the network has at least one network controller capable of altering the allocation of at least some of the channels allocated to a given cell and the output power of the transmitter in a cell;

the method comprising:

a monitor transceiver located in at least a plurality of monitored cells,

monitoring operational parameters in each such cell;

transmitting at least some of the operational parameters to the network controller; and

altering at least one of the allocation of the channels and the output power of at least one cell.

24. The method of claim 23, at least one of the monitored cells having a plurality of cell sectors with different channels allocated to different sectors within the cell, the method further including altering the allocation of the channels to different cell sectors.

25. The method of claim 24, each monitor transceiver further including means for initiating calls over the cellular network and means for determining operational parameters associated with said calls and the method further comprises:

transmitting at least some of the operational parameters associated with the calls to the controller; and

altering the allocation of at least some of the channels between cell sectors in response to the transmitted data.

26. In a cellular telephone transceiver unit for making telephone calls over a cellular telephone network, the unit comprised of a housing defining an earpiece containing a speaker, and a mouthpiece containing a microphone, the housing containing a keypad for a user to control the unit, an antenna, a transceiver responsive to the microphone, the keypad and the antenna, the improvement comprising:

a radio modem mounted within the housing for transmitting data over a data network; and

a processor mounted within the housing and coupled to the transceiver, the processor monitoring the status of any telephone call made by the transceiver and providing at least some of the data related to a parameter of at least some of the calls to the digital radio modem for transmission over the data network.

27. The unit of claim 26, wherein the processor only provides to the modem data obtained within a predetermined time interval of a predetermined event occurring in at least one call.

28. The unit of claim 27, wherein the predetermined event is at least one of a dropped call, a blocked call, a signal to noise ratio below a predetermined threshold, noise above a predetermined threshold, reorders, fast busy, RSSI below a predetermined threshold and a no service condition.

29. An apparatus for testing the quality of a radio telephony network having a plurality of transmit and receive channels, the testing being done according to at least one testing scenario comprising:

means for storing control data representative of the testing scenario;

at least a first cellular transceiver assembly;

a controller, the controller being responsive to at least some of the control data to operate the at least first cellular transceiver assembly and to receive operation parameters associated with the progress of a call made using the transceiver; and

a radio modem responsive to the controller for transmitting at least some of the operation parameters over a data network.

30. The apparatus of claim 29, wherein the means for storing the control data comprises a replaceable module whereby the test scenario may be altered.

31. The apparatus of claim 29, wherein the means for storing the control data comprises an alterable, non-volatile memory and the apparatus has a means for altering the control data.

32. The apparatus of claim 29, wherein the means for storing the control data comprises an alterable memory responsive to control data transmitted to the apparatus over the data network.

33. The apparatus of claim 29, wherein the controller has an alterable program memory storing a program to enable the apparatus to operate at least first cellular phone in different manners and the apparatus has means for reprogramming the program memory in response to a new program transmitted over the network.

34. The apparatus of claim 29, wherein the apparatus has a means for determining the position of the apparatus and the modem may receive transmitted scenarios for vehicles located within a predetermined portion of the cellular system, and the controller having:

an alterable memory for storing a scenario for the apparatus to perform to measure parameters associated with the performance of the network; and

means responsive to the position determining means for causing the contents of the alterable memory to be stored with the transmitted scenarios.

35. A method for dynamically reconfiguring a cellular network, the network comprised of a plurality of cells, each cell having a plurality of channels for communication and each cell having at least one of a cellular switch or a cell site having a controllable selection of usable communication channels and power levels, wherein the network has at least one network controller capable of transmitting control signals altering at least one of the output power level and the allocation of at least some of the channels allocated to a given cell and means for providing parametric data relating to calls being placed over the telephone network;

the method comprising:

receiving the parametric data relating to at least some of the calls;

analyzing the parametric data for problems and trends in the performance of various cells in the network; and

transmitting control signals to the at least one of the cellular switches or cellular sites to alter the operation of said at least one of the cellular switches or cellular sites.

36. The method of claim 35, wherein the control signals alters the output power of the channels of said at least one of the cellular switches or cellular sites.

37. The method of claim 35, wherein the control signal alters the selection of channels of said at least one of the cellular switches or cellular sites.

38. The method of claim 35, wherein the parametric data includes spectra data of the audio signal and the method of analyzing the parametric data comprises comparing the spectra with stored spectra patterns to determine the nature of interference with respect to a call.

39. The method of claim 38, the method further including receiving position information associated with the parametric data received for a call.

40. The method of claim 35, wherein the network has at least one tiltable antenna and transmits a control signal to the antenna to change the tilt of the antenna and thereby reduce interference.

41. The method of claim 39, wherein the position information is the cell from which the transceiver is operating.

42. The method of claim 35, wherein the analyzing step is performed at least in part by the mobile telephone switch.

43. An apparatus for testing a cellular telephone network for a geographic area operable in response to cellular transceivers and said area being serviced by a secondary digital radio data network, the apparatus comprising:

a controller responsive to at least one transceiver for receiving parameters from said at least one transceiver relating to a telephone call made with the transceiver; and

a modem responsive to the controller for transmitting the data over the network.

44. The apparatus of claim 43 for transmitting data, the controller causing the modem to transmit data over the network only in response to a predetermined condition.

45. A cellular telephone transceiver unit for making telephone calls over a cellular telephone network having control channels, the unit comprised of a housing defining an earpiece containing a speaker and a mouthpiece containing a microphone, the housing containing a keypad for a user to control the unit, an antenna, a transceiver, responsive to the microphone, the keypad and the antenna, the unit further comprising:

a radio modem mounted within the housing for transmitting data over the control channel;

a processor mounted within the housing and coupled to the transceiver, the processor monitoring the status of any telephone call made by the transceiver and providing at least some of the data related to a parameter of at least some of calls to the radio modem for transmission over the control channel.

46. The apparatus of claim 44, wherein the data is transmitted according a packet data protocol.

47. A method for testing a portion of an area of a cellular telephone network, the method comprising:

providing a plurality of network performance terminals moving throughout the geographic area of the network, at least some terminals having a means for determining its location within the network area and capable of measuring a variety of parameters related to network performance in response to a scenario stored in an alterable memory;

transmitting to the network performance terminals within a predetermined portion of the cellular network a scenario for testing; and

having the terminals while within the predetermined portion of the network measure the parameters stored in the alterable memory.

48. A method for testing a paging network comprised of an automatic paging equipment responsive to touch tones provided by a DTMF telephone dialer, the method comprising:

providing at least one pager moving throughout the network;

repetitively signaling to the at least one pager through the dialer;

determining if the pager has received the page within a predetermined interval of each signal; and

recording the location of the pager when a page is not received within the interval.

49. The method of claim 48 further including:

providing means for measuring parameters associated with the signaling of the paging; and

recording at least some of the measured parameters.

50. A method for testing the performance of a digital radio data network, the method comprising:

providing at least one node of the network moving throughout the network;

transmitting information over the network from the mobile node;

measuring parameters associated with the transmission of the information; and

recording the measured parameters.

51. The method of claim 50, the method further comprising:

providing at least one fixed node in the network;

transmitting information from the fixed node;

measuring parameters associated with the transmission of the information from the fixed node at the mobile node; and

recording the measured parameters.

52. The method of claim 50, the measured parameters being at least one of signal strength, signal to noise ratio, bit error rate and frame/packet errors.

53. A method for measuring parameters associated with communications over a cellular radio network, the method comprising:

providing a controller having a modem at a fixed site and coupled to the network by a land line;

providing a cellular transceiver moving throughout the network;

measuring a parameter associated with a call placed by the controller; and

recording the measured parameter.

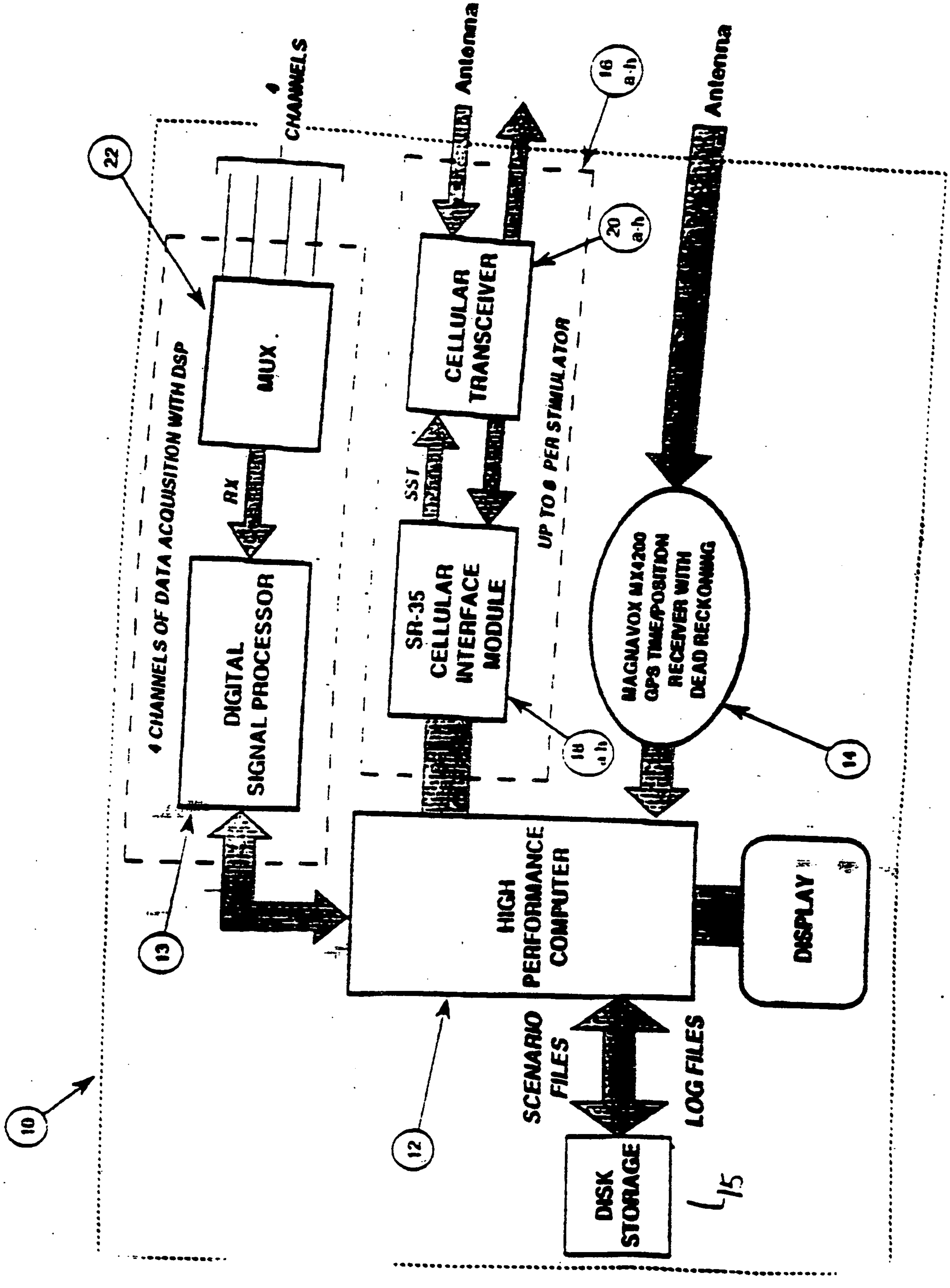

4 CHANNELS
Antenna
Antenna
22
MUX.
RX
DIGITAL SIGNAL PROCESSOR
4 CHANNELS OF DATA ACQUISITION WITH DSP
13
CELLULAR TRANSCEIVER
20 a-h
16 a-h
SST
SR-35 CELLULAR INTERFACE MODULE
18 a-h
UP TO 8 PER STIMULATOR
MAGNAVOX MX4200 GPS TIME/POSITION RECEIVER WITH DEAD RECKONING
14
HIGH PERFORMANCE COMPUTER
12
DISPLAY
SCENARIO FILES
LOG FILES
DISK STORAGE
15
10

Figure 1

Figure 2

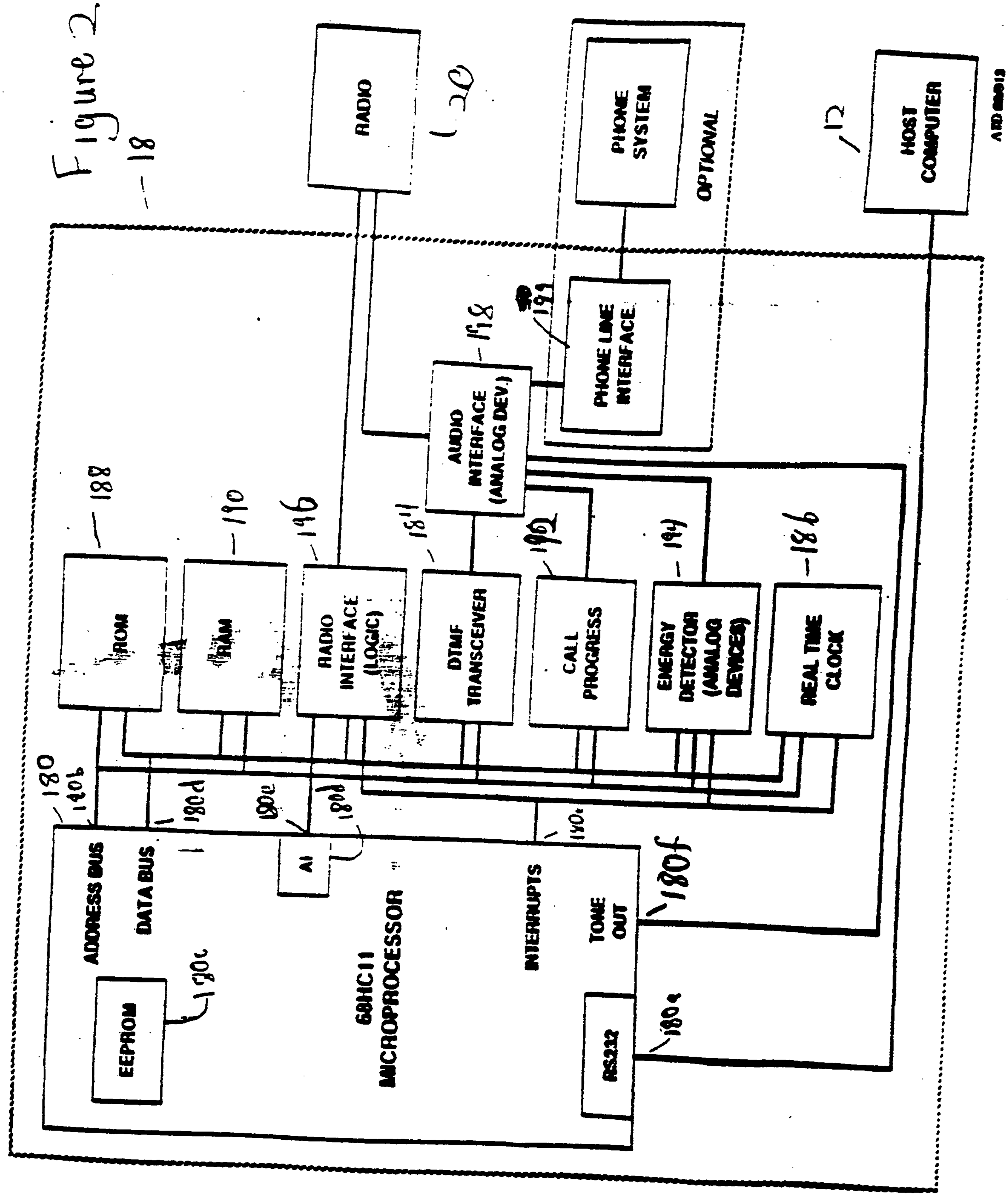
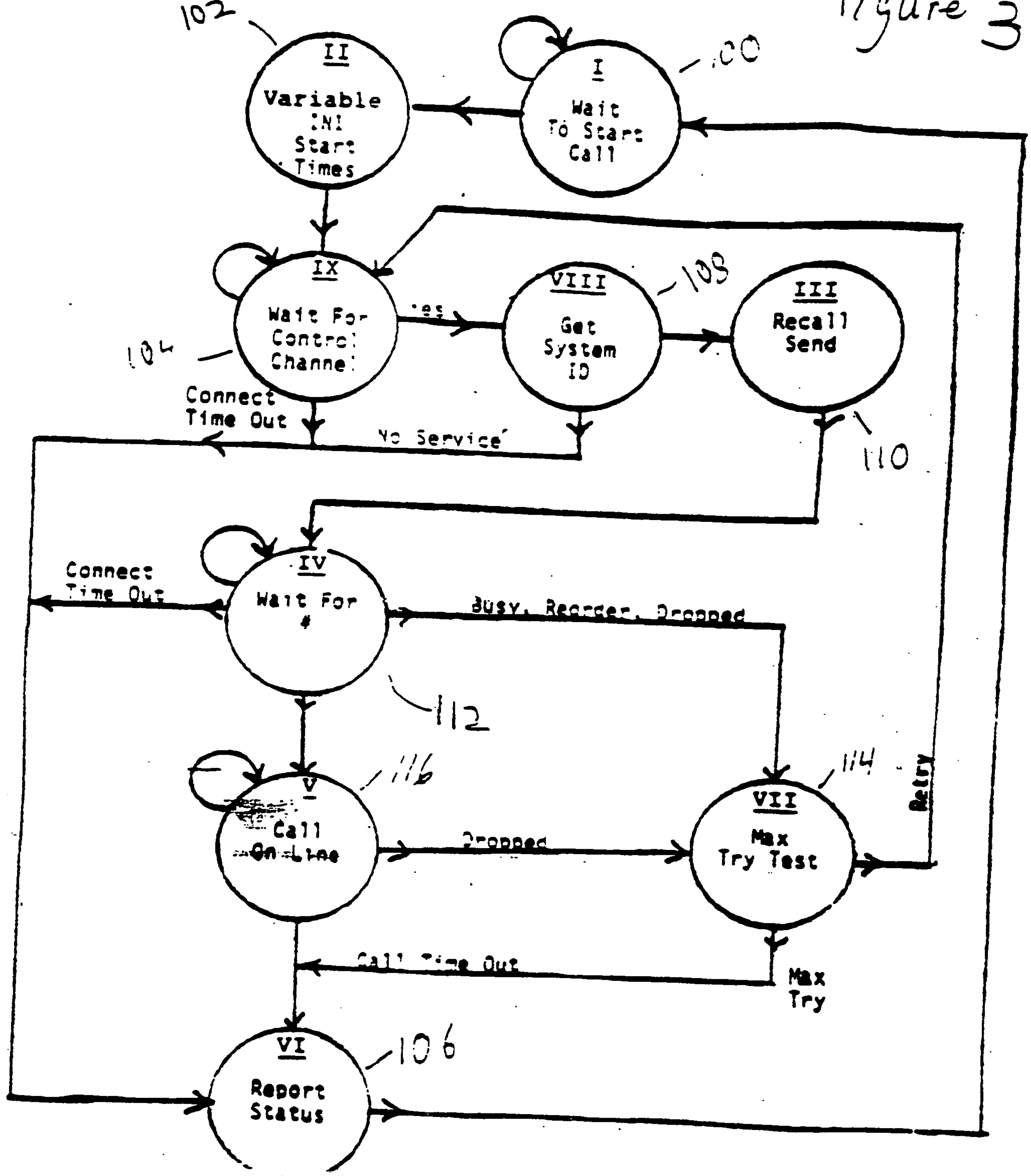

RADIO
20
PHONE SYSTEM
OPTIONAL
12
HOST COMPUTER
18
PHONE LINE INTERFACE
194
AUDIO INTERFACE (ANALOG DEV.)
198
188
ROM
190
RAM
196
RADIO INTERFACE (LOGIC)
184
DTMF TRANSCEIVER
192
CALL PROGRESS
194
ENERGY DETECTOR (ANALOG DEVICES)
186
REAL TIME CLOCK
180
180b
180d
180e
180g
180c
180f
ADDRESS BUS
DATA BUS
AI
INTERRUPTS
TONE OUT
EEPROM
180c
68HC11 MICROPROCESSOR
RS232
180a

Figure 3


102
II
Variable
INI
Start
Times
I
Wait
To Start
Call
100
IX
Wait For
Control
Channel
104
Yes
VIII
Get
System
ID
108
III
Recall
Send
Connect
Time Out
No Service
110
IV
Wait For
#
Connect
Time Out
Busy, Reorder, Dropped
112
V
Call
On-Line
116
Dropped
VII
Max
Try Test
114
Retry
Call Time Out
Max
Try
VI
Report
Status
106

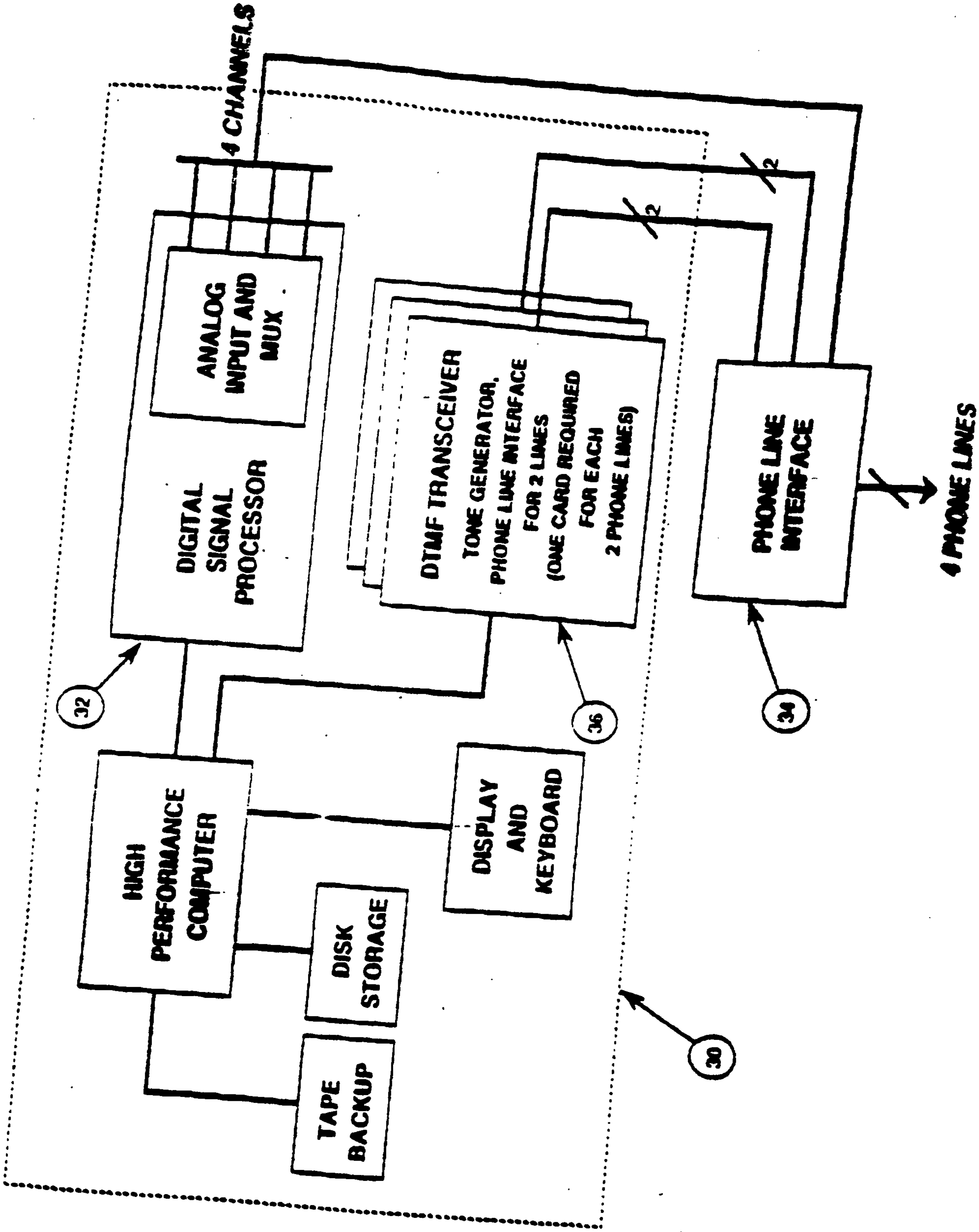

4 CHANNELS
ANALOG INPUT AND MUX
DIGITAL SIGNAL PROCESSOR
32
DTMF TRANSCEIVER
TONE GENERATOR.
PHONE LINE INTERFACE
FOR 2 LINES
(ONE CARD REQUIRED
FOR EACH
2 PHONE LINES)
36
2
2
PHONE LINE INTERFACE
34
4 PHONE LINES
HIGH PERFORMANCE COMPUTER
DISPLAY AND KEYBOARD
DISK STORAGE
TAPE BACKUP
30

Figure 4

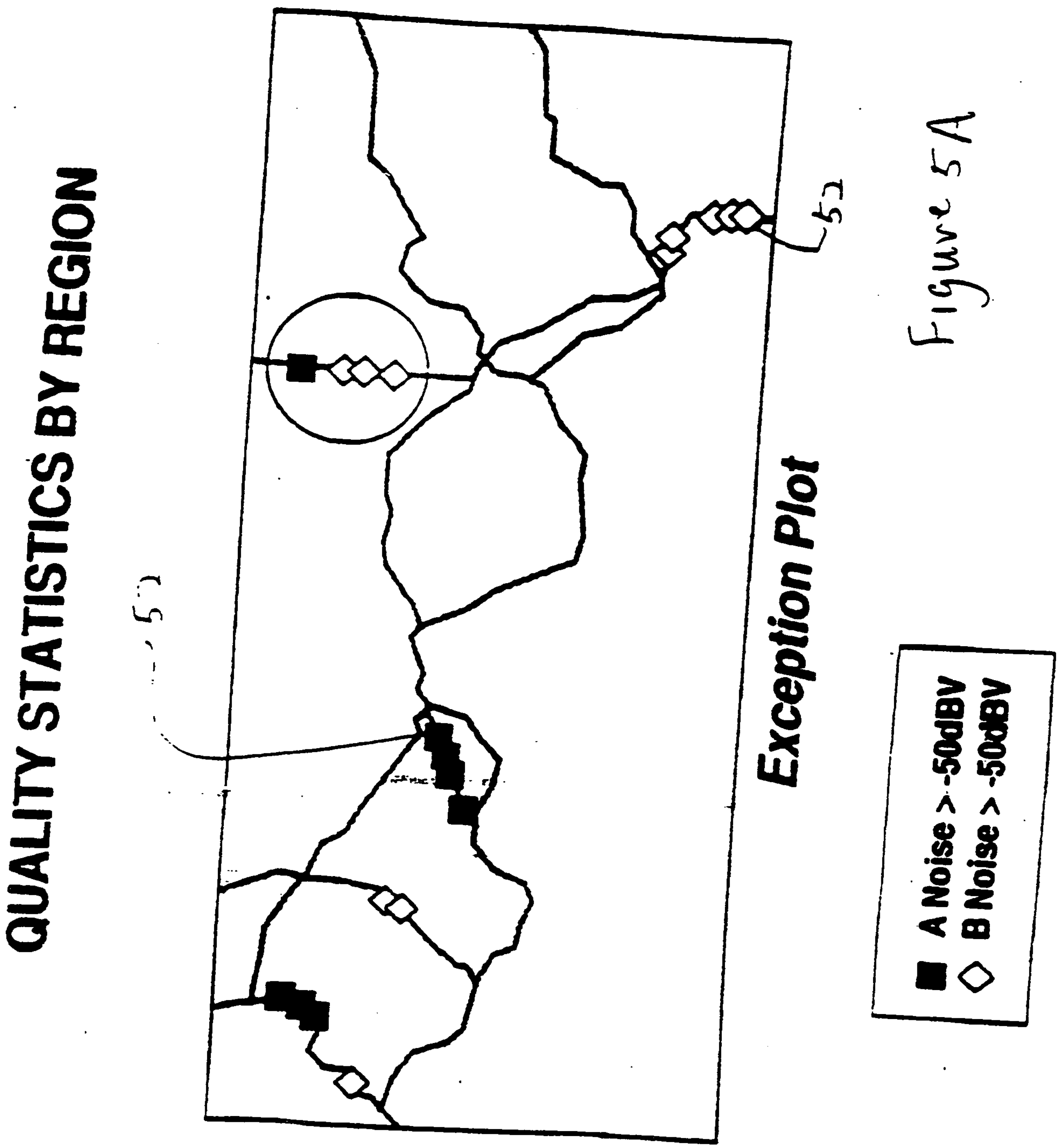

QUALITY STATISTICS BY REGION
Exception Plot
52
52
A Noise > -50dBV
B Noise > -50dBV

Figure 5A

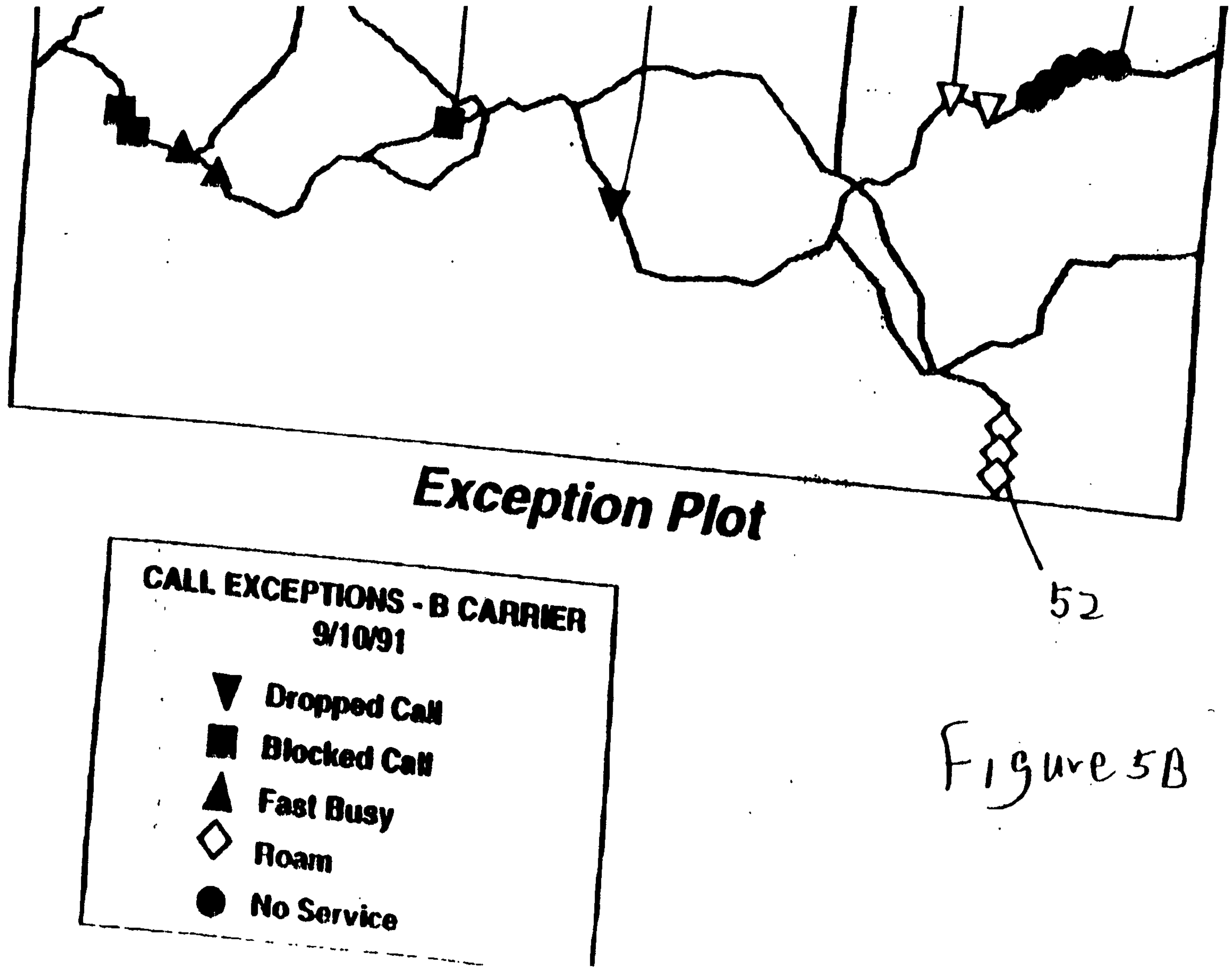


Figure 5B

UTILITY VEHICLE
NETWORK PERFORMANCE TERMINAL

179

2
270
230
210

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